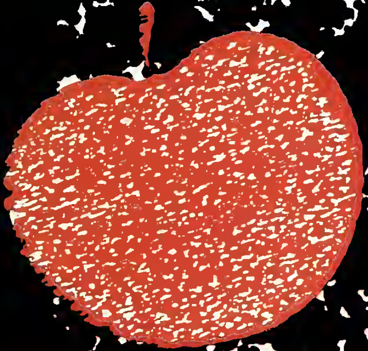
Biomedical Research:

The Next Generation of Scientists



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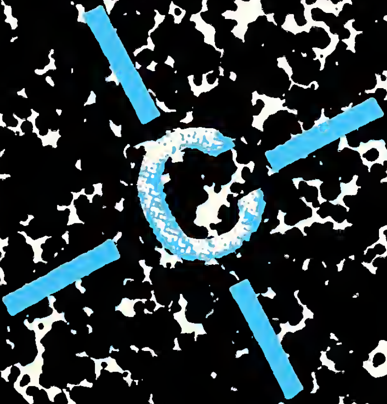

THE NEXT GENERATION OF SCIENTISTS

Proceedings of the 59th Meeting of the Advisory Committee to the Director
National Institutes of Health
May 18, 1989

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EXECUTIVE SUMMARY

The 59th meeting of the Advisory Committee to the Director, NIH, addressed issues associated with recruiting and retaining future scientists. The first session provided a comprehensive overview of projected trends in scientific manpower. The second session reviewed initiatives already proposed or underway to help reverse these trends and analyzed possible other options for intervention.

Current Perceptions of the Future Supply of Scientists

Scientific research in the United States, especially biomedical research, currently appears to be very strong according to available indicators. Between now and the year 2000, however, 25 million new workers (net amount) will have to be added to the labor force. A large proportion of these new scientists will be women and minorities, necessitating a change in traditional strategies for recruiting and retaining students interested in science.

Arrayed against this future demand for scientists is a projected decline in the number of undergraduate degrees awarded. As a result, by the year 2000 the United States will have several hundred thousand fewer scientists and engineers and thousands of fewer graduates with doctorates than will actually be needed.

The supply of scientists is even more critical now than it has been previously due to an expanding population, a reliance on scientists and engineers to help the United States maintain its international competitiveness, and the need to help educate citizens who, as society grows more scientific and technological, must be scientifically knowledgeable so they can make informed choices.

These projections, nevertheless, mask an enormous loss of scientific potential as students lose interest in science while progressing through the so-called pipeline model of education in the United States. It is essential, therefore, to also look at factors that affect the quality of science education and career choices of students.

The national resolve of the United States to solve these problems appears to be unclear. Because there is little agreement on the exact number of future scientists needed, concerns over making changes that may lead to a surplus of scientists has hindered progress. Whereas the speakers generally agreed that the large proportion of foreign graduate students in the United States represents a solution to the projected decline in scientific manpower in the United States, there is still some concern that such students may be recruited by their native countries.

There is also an unequal distribution of resources, with U.S. universities and various national laboratories relatively rich in science resources while local school systems are relatively poor. Furthermore, congressional policy focuses on shifting resources around, a strategy that could adversely affect medical research, rather than on increasing resources to the levels needed in the United States.

These policies have an adverse impact on the NIH. Senior scientists at the NIH have been leaving for higher salaries at universities. The NIH program for extramural research currently approves and funds, generally below the recommended amounts, only one research application in four. Such difficult conditions do little to encourage students to begin a science career.

Strategies for Increasing the Pool of Biomedical Scientists

Elementary and Secondary School Strategies

The teaching of science in elementary and secondary school poses significant problems. In kindergarten and first grade, students show an interest in science that declines through the school years. Consequently, U.S. students fare poorly on science tests designed for international comparisons.

Part of the problem may rest with the selection and training of teachers. It is still unclear whether science and mathematics teachers are best trained in their respective academic departments or in education departments. Furthermore, the impact of even good teachers can be diminished if schools lack the necessary science resources. Unfortunately, few elementary and secondary schools benefit from partnerships with industry as universities and colleges do.

Another critical area involves curriculum changes. A careful balance must be made between giving too much information and just enough to maintain student interest. In addition, methods of evaluation must be used to determine whether the curriculum changes make a difference. Educators must realize that there are no short-term solutions to these problems.

College and University Strategies

The problems at the undergraduate level are somewhat different. Research opportunities for undergraduates, an important factor in recruiting and retaining science students, varies with the institution. As a consequence of Federal R&D funding patterns, many faculty at institutions where most of the undergraduates are concentrated do not receive research support, depriving students of the opportunity to become involved in research. Furthermore, the aging of faculty at U.S. academic institutions means that more young Ph.D.'s are likely to become faculty members of these same underfunded institutions.

Women, expected to make up a significantly greater proportion of the future generation of scientists, still find opportunities for advancement restricted. Such situations must change if women are to be encouraged to remain in science.

Strategies Developed by the NIH

The NIH historically has always recognized the interdependence of research and training through its many fellowship and training programs. Minority students, for example, can benefit from the Minority Access to Research Careers (MARC) programs. The NIH has also maximized its training resources by recycling unclaimed fellowships into other fellowship programs. In addition, the NIH has proposed shifting some research project grant funds into training areas.

Furthermore, the NIH has developed symposia on Biomedical Careers for various minority populations. The NIH is also developing programs with the private sector to make students more aware of career opportunities in the health sciences. Dr. Wyngaarden has also established an advisory group to develop an action plan for attracting young people into biomedical research.

Initiatives Taken for Elementary and Secondary Education

The American Association for the Advancement of Science (AAAS), with support from the Mellon and Carnegie Foundations, is determining what students need to learn about science, mathematics, and technology by the time they are 17 or 18 years old. The AAAS is also recruiting 150 teachers, including minorities, to help design the curricula and to then champion their introduction into the schools on a national rather than a local basis.

The National Assessment of Educational Progress, a government-sponsored assessment program, has already found that the use of various instructional techniques, the opportunities for hands-on learning of science, efforts to relate science to everyday life, and emphasis on the cultural value of science all help improve the teaching of science.

A task force from the National Science Teachers Association (NSTA) is also looking at how laboratory science is being taught in secondary schools throughout the United States. The NSTA has developed four initiatives including Staff Development and Teacher Preparation, which involves science teacher certification; curriculum structure and reform; methods of instructional support through regional science centers; and the use of new technologies such as videotape, computers, and compact discs to help distribute research results.

Similarly the Hoffmann-La Roche Company, through its Department of Community Affairs, offers various research opportunities to students and teachers, furnishes instructional resources that science teachers need, offers company scientists to help develop curriculum content, holds seminars to train teachers, and assists minority students and their families to become familiar with science.

Strategies for Colleges and Universities

Federal agencies, science and health organizations, and foundations are all involved in undergraduate education. A recent program of the National Science Foundation (NSF) called the Experimental Program to Stimulate Competitive Research, for example, allows institutions in States receiving relatively little Federal support to increase their scientific productivity.

The American Medical Association (AMA) is looking at the twin issues of the future availability of scientists and the level of public literacy in science. Videotapes prepared by the AMA for use in high schools and colleges discuss the challenges and rewards of a medical career.

The American Heart Association (AHA) supports both investigator training and research through various awards and fellowship programs. Some provide undergraduates with summer laboratory research experience in a qualified laboratory. Such programs are important for the recruitment and retention of science students.

One of the Federation of American Societies for Experimental Biology's (FASEB) intervention programs involves sending scientists to minority institutions for several days to talk to students. Such programs reach a wide number of institutions at a nominal cost. In addition, several FASEB societies provide teachers from liberal arts colleges with summer laboratory experiences.

Foundations also play an important role in strategies aimed at undergraduate science students. The Howard Hughes Medical Institute is supporting programs to encourage more student interest in science. The Robert Wood Johnson Foundation is supporting programs in those high schools and colleges that excel in graduating students with a strong interest in health and medicine. More recently, the Foundation began its Minority Medical Faculty Development Program that supports physicians interested in science careers, particularly in biomedical research.

Recommendations for Congressional Action

- Congress should realize the importance of science to the national defense.
- Congress should pass legislation to help fund elementary school science programs in every State and to develop throughout the country regional consortiums of business, industrial, and educational leaders.
- Congress should consider a surtax on the military budget to be used to help support the training of graduate students of value to defense research. Congress should also consider a similar plan for the Department of Agriculture and other Federal agencies.

Recommendations for the NIH

- The NIH should assume a leadership role in developing partnerships with the private sector to support the training of biomedical investigators.
- The NIH should press for the reintroduction of training grants and training support at levels comparable to those in the late 1960's and early 1970's, including summer fellowships for medical students to introduce them to laboratory research.
- The NIH should develop programs to help underwrite the costs of training physicians for medical research.

- The NIH should work vigorously to reinstitute training support at every level from medical school through postgraduate training, by both increasing the number of training grants and their annual stipends. This should not be done at the expense of the RO1 grants.

- The NIH should work to implement stability in some of the NIH research career fellowship programs.

Recommendations for Elementary and Secondary Education

- Plans should be developed to stimulate science teachers through such programs as summer fellowships for hands-on laboratory experience in industry.

- Efforts should be made to attract the best young people possible into elementary and secondary school teaching.

- Television programs and other resources such as science centers and museums, zoos, botanical gardens, and aquariums should be used to heighten the interest of youngsters in science.

- Science curricula must be made more exciting with less emphasis on memorization and more emphasis on the general principles of scientific thinking.

- Linkages should be created between industry, colleges and universities, and elementary and secondary schools.

- A national emergency should be declared in science, technology, and mathematics education.

- New approaches to teacher eligibility and certification in science and mathematics should be developed.

- Communication between scientists and the general public must be improved.

- Science programs should be developed to interest students in science at earlier ages.

- Novel approaches are needed, such as regional centers for excellence, national standards to measure achievement, and training programs for those who wish to become science advocates.

- The Federal Government, rather than local jurisdictions, should assume the leadership role on education issues.

- The United States must devote more resources to improving the teaching of science at the precollege level. Other Federal agencies in addition to the National Science Foundation should be involved in these efforts.

Recommendations for College and University Education

- Minority students and women should be brought into the laboratory as soon as possible and introduced to scientists who can act as effective role models and mentors.
- Medical students must be given hands-on laboratory experience as early as possible in their training.
- Physicians must be adequately supported while they train for research careers.
- Retired scientists and administrators from industry should be encouraged to teach at small colleges as a means of improving science education at these institutions.

General Recommendations

- The scientific community must direct the attention of the Congress and the press to the problems and limitations inherent in today's science and mathematics education.
- Scientists must also use the press more effectively to educate and inform the general public.
- The private sector should be encouraged to support graduate studies in the sciences but should not be expected to administer these programs.

AGENDA

59th Meeting of the
Advisory Committee to the Director, NIH

May 18, 1989

Lecture Hall
Mary Woodard Lasker Center for
Health Research and Education (The Cloister)
Building 60, National Institutes of Health
Bethesda, Maryland

BIOMEDICAL RESEARCH: THE NEXT GENERATION OF SCIENTISTS

Morning Session

8:30	Opening Remarks	James B. Wyngaarden, M.D.
8:45	Science in America: The View from Congress	The Honorable Mark O. Hatfield

I. Statement of the Problem

9:15	Trends Affecting the Future Supply of Scientists	David Eli Drew, Ph.D.
	Discussion	
10:00	**Break**	
10:15	The Quality of Science Education	Bassam Shakhashiri, Ph.D.
	Discussion	
11:00	Recruitment of Women and Minorities in Science	Sue Kemnitzer, Ph.D.
	Discussion	
11:45	**Lunch**	

Afternoon Session

II. Initiatives Presently Proposed or Underway to Address Issue

1:00	The National Initiative for Science and Technology Education	Jerod M. Loeb, Ph.D.
1:30	Project 2061	F. James Rutherford, Ph.D.
	Discussion	
2:00	Essential Changes in Secondary School Science—Scope, Sequence, and Coordination	LaMoine L. Motz, Ph.D.
	Discussion	
2:30	**Break**	

III. Development of Additional Options for Intervention

2:45	Moderator:Jay Moskowitz, Ph.D. Panelists:Ethan Halm Rodman D. Starke, M.D. Daniel F. Burton, Ph.D. Rosemary Brunner W. Maxwell Cowan, M.D., Ph.D. Robert W. Krauss, Ph.D. Ruby P. Hearn, Ph.D.	
4:00	**Discussion**	
4:15	Closing Remarks	James B. Wyngaarden, M.D.
4:30	**Adjournment**	

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THE NEXT GENERATION OF SCIENTISTS

MORNING SESSION

Opening Remarks

Dr. James B. Wyngaarden
Director, National Institutes of Health

Dr. Wyngaarden began by introducing several new members of the Advisory Committee, including Dr. Frederick A. King, Director of the Yerkes Regional Primate Center, Emory University; Rodney W. Nichols, Executive Vice President, Rockefeller University; Dr. Matthew D. Scharff, Director, Albert Einstein College of Medicine; and Dr. Philip Leder, John Emory Andrus Professor of Medicine, Department of Genetics, Harvard Medical School (not in attendance).

Dr. Wyngaarden then turned to a brief overview of the day's subject, "The Next Generation of Scientists." He emphasized that the NIH historically has always recognized the interdependence of research and training through its many fellowship and training programs. But, he noted, even those programs may be unable to deal with the shortages projected by numerous demographic and other trends projected for the year 2000. These trends range from a decreased flow of students through the educational pipeline to potentially high turnover of college faculty positions and significantly increased industrial demand for biomedical scientists.

Dr. Wyngaarden then introduced Senator Mark O. Hatfield, Senior Senator from the State of Oregon, ranking minority member of the Senate Appropriation Committee, and a former university professor and Dean.

Science in America: The View from Congress

The Honorable Mark O. Hatfield
United States Senate

Senator Hatfield first praised the NIH for its compassionate health care treatment of patients. He then discussed the central issue of supply and demand of the Nation's scientists. He noted, for example, that whereas research appropriations for AIDS have nearly quadrupled over the past 4 years, thereby increasing the demand for trained biomedical scientists, the proportion of high schools offering hands-on laboratory courses has dropped by more than 50 percent over the past decade. And only 50 percent of the high school teachers presenting science courses are academically qualified to do so by the National Science Teachers Association (NSTA). The result, concluded Senator Hatfield, is a national crisis.

Congressional response, he continued, focuses on a redistribution of resources, a strategy that is likely to first affect medical research adversely. Currently, for example, only one research application in four is approved and funded at the NIH, and even those granted average 10 to 12 percent less than the recommended funding levels. Current plans call for also eliminating funding for more than 1,000 NIH research trainees. In addition, because the salary gulf between senior scientists at the NIH and those in academia has widened, the NIH has lost 28 percent of its senior bench scientists over the last 10 years.

Senator Hatfield and others are calling on Congress to make science and technology education a national priority to help prevent further erosion of the scientific enterprise in the United States. A bill now being drafted will, for example, recommend the funding of four model elementary school science programs in every State, the offering of 50 percent matching funds to upgrade elementary science equipment and curricula, and the creation of regional consortiums throughout the country of business, industrial, and educational leaders.

Senator Hatfield further suggested that a surtax of 1 percent be put on the military budget and that the money be used to help replenish the pool of graduate research students being used for defense research. A similar approach, he noted, could be used for the Department of Agriculture and other agencies as a form of automatic reinvestment in our Nation's future.

Dr. Wyngaarden thanked Senator Hatfield for his remarks and asked what could be done to attract and interest students in science. Senator Hatfield noted that technological resources today, such as computers and video equipment, strongly stimulate young students but that the educational system depends on teachers to maintain that interest. Without opportunities to stimulate teachers through such programs as summer fellowships for hands-on laboratory experience in industry, for example, the likelihood of educators being able to convey the excitement of science to students will remain small.

Dr. Mihich suggested that recruiting and retaining the next generation of scientists would also have a positive impact both on the national defense of the United States and the budget deficit. Yet students are being discouraged from going into science by poor teaching as early as elementary school. Those who retain an interest, despite their teachers, often drop out in college because the future of scientific research in the United States appears so clouded.

Senator Hatfield noted that the linkage of science to the national defense was a valid issue and one that had been used historically for various other programs as well. But it remains necessary to convince both the President and the Congress of the validity of this argument so that it becomes possible to alter our national priorities. Furthermore, said Senator Hatfield, whereas efforts are underway to strengthen universities and colleges through industrial collaborations, few partnerships exist to benefit the elementary and secondary schools. Development of scientific talent must occur at all levels and not just at the upper end of the scientific manpower pipeline.

Dr. Wyngaarden thanked Senator Hatfield for his insights and, after a brief recess, introduced the representatives of the National Advisory Council. (See attachment for list of participants.) Dr. Wyngaarden then noted that the report of the Human Fetal Tissue Transplantation Research Panel, arising from the December 14, 1988, meeting of the Advisory Committee to the Director, had been sent to Dr. Windom, the Assistant Secretary of Health, together with a summary of the deliberations and recommendations of the Advisory Committee. While these materials are under review and a moratorium on the use for transplants of human fetal tissue from induced abortions remains in effect, the Department of Health and Human Services has approved the public distribution of both reports.

Dr. Wyngaarden then reported on the NIH's efforts to attract young people to careers in science and to increase the number of well-trained minority scientists in medical research. In 1972, for example, the NIH established the Minority Access to Research Careers (MARC) program, to provide those minority students having research potential with special training opportunities and incentives in biomedical research. The MARC Honors Undergraduate Research Training Program, established in 1977, provides medical research training to minority undergraduates. The MARC Predoctoral Fellowship Awards for support of minority doctoral studies were established in 1982. In addition, there are the MARC Faculty Fellowships, MARC Visiting Scientist Awards, Minority High School Student Research Apprentice Program, Minority Biomedical Research Support Program, and Research Centers in Minority Institutions Award.

Furthermore, continued Dr. Wyngaarden, the NIH together with the Indian Health Service recently sponsored a symposium on Biomedical Careers for Native American and Alaskan Natives. Another symposium will be held this fall for Hispanic students, and two more are planned for next year. The NIH is also cooperating with 95 private sector companies and the New Jersey Business, Industry, and Science Educational Consortium to develop an education package called Health Careers in the Health Century to heighten student awareness of multiple career opportunities in the fields of health, medicine, and research.

In addition, the NIH has been invited to develop an education project with NASA to stimulate the interest of high school students in space life sciences. Dr. Wyngaarden further noted that he had established an advisory group to help develop an action plan for attracting young people into biomedical research.

In introducing the first morning session, Dr. Wyngaarden observed that the purpose of the meeting is to "examine the evidence supporting recent demographic and sociological trends, assess the implications of these current trends for the future adequacy of the pool of biomedical researchers, and suggest strategies for countering negative trends and for maintaining the quality and level of effort of the research enterprise."

I. STATEMENT OF THE PROBLEM

Trends Affecting the Future Supply of Scientists

Dr. David Eli Drew
Professor of Education and Public Policy
Claremont Graduate School

Dr. Drew explained that a sizable proportion of graduate students in the United States comes from other countries. This may not be a particular problem, because more than half of these students stay in this country, thereby replenishing the needed pool of researchers. However, dependence on foreign students may make the United States research enterprise vulnerable to changes in immigration resulting from either legislation or inducements by other countries to retain students once they have graduated from universities in this country. Furthermore, students in the United States need to be enthusiastic and well trained in science as well.

Another issue concerns why student interest in science, initially lively in kindergarten and first grade, declines through the school years. Some research suggests that the sharpest declines occur in junior high school. In fact, schools in this country generally are not doing as well as they should in recruiting and retaining students in science throughout the precollege years. Evidence suggests that, in general, the greater the number of science courses that students take, the less they like science.

Data from the Higher Education Research Institute show that over the past 22 years, the number of teachers majoring in such areas as mathematics or biology has markedly declined. In addition, as professional opportunities for women have increased in areas other than teaching, fewer women have gone into education. So an important part of the problem of recruiting and retaining student interest in science begins with the training and selection of elementary and secondary school teachers.

Dr. Drew advanced two possibly controversial notions: first, that the quality of the teacher is more important than the quality of the curriculum and, second, that good teachers are born, not made. As a result, Dr. Drew recommended that efforts should be made to attract the best young people possible into elementary and secondary school teaching.

The problem at the undergraduate level is somewhat different. At some schools, students are taught science by people who themselves are not doing any research. Figures show that 13.2 percent of Federal R&D funds go to only three institutions, with almost half of Federal R&D funds distributed among only the top 20 schools. As a result, many faculty at institutions where most of the undergraduates are concentrated do not receive research support. Consequently, students at those institutions do not have an opportunity to witness or participate in research. Furthermore, because the aging of faculty at U.S. academic institutions creates turnover and subsequent employment opportunities, the best young Ph.D.'s from the top academic departments frequently end up on the faculty of these same underfunded institutions.

Programs at the National Science Foundation (NSF), for example, have tried to address these problems. One such program was the Centers of Excellence Program conducted in the 1960's and 1970's that awarded more than $230 million to improve research at a small set of second-tier institutions. The NSF has recently also developed the Experimental Program to Stimulate Competitive Research. This program has parlayed a limited amount of funding, given to institutions in States receiving relatively little Federal support, into increased scientific productivity.

Creating new programs is one side of the issue. Evaluating how well those programs are working is the other. Dr. Drew recommended that better data are needed with perhaps better resolution of individual details.

Discussion

Dr. Wyngaarden noted that a shift in Federal policy has affected foreign students participating in the NIH Fogarty Center programs. At one time, because foreign students were regarded as competing for jobs with students from this country, barriers were raised against allowing foreign students to remain in the United States. Today that view has shifted, and foreign students are considered part of the solution to where the next generation of scientists will come from, rather than the problem. As a result, students from abroad are encouraged to remain in the United States, and the means to do this are facilitated.

Dr. Mihich remarked that the data on how the attitude of elementary students toward science changed with time raised an important question: Is it a matter of simply increasing the exposure of young students to science or a matter of increasing the type of exposure to science that is most important? Dr. Cooper commented that it might be important to find out what areas of interest drew students' attention as science became less exciting to them. Dr. Reider mentioned the disparity in funds available for science students in institutions throughout the country, particularly those that are producing large numbers of teachers.

Dr. von Hippel also noted that some foreign governments were more actively recruiting graduate students to return home once they received their degrees.
Dr. Goldhaber commented that the large proportion of Asian students studying science and engineering was probably due to their lack of familiarity with the language and, consequently, a desire to avoid courses that require a great deal of communication in English. Furthermore, shifts in what U.S. students find exciting might also be the result of the large number of options students encounter in this country compared to other countries. Dr. Pender observed that issues of science education remain connected with the generally low level of science literacy in families in the United States.

Dr. Palade remarked that political stability and the strength of the scientific enterprise now conferred on the United States the mantle of leadership in science training, similar to the role historically of other countries such as Germany. Political events in the Communist countries, he noted, would likely increase demands for further training of students here. The question therefore, noted Dr. Palade, was whether the United States was prepared to take advantage of these changing situations.

The Quality of Science Education

Dr. Bassam Shakhashiri
Assistant Director, Science and Engineering Education
National Science Foundation

Dr. Shakhashiri began by stating that the issue of the supply of scientists is more critical now than it was even in the immediate post-Sputnik era. He stated three reasons for this belief. First, the population has increased by about 50 million and, consequently, so has the need for more qualified teachers at all educational levels. Second, the United States needs to maintain its international competitiveness, which requires a good supply of scientists and engineers. Third, and most important, is that living in a more advanced scientific and technological society calls for a more educated citizenry to confront the multitude of environmental and other problems that now prevail.

Thus, the problem of supply is more complicated and must address the needs of educating both the specialist and the nonspecialist. If scientists fail to communicate and inform the public, they risk losing public support. These efforts to communicate are particularly important because of the widening gap between scientists and nonscientists.

The trend in the number of 22-year-olds receiving bachelor's degrees is declining, while the adult population enrolling at colleges and universities is increasing. Currently, only about 4 percent of the 22-year-old population receives a degree in the natural sciences or engineering. A decline is also seen in the number of freshmen who, after announcing their interest in science or mathematics, actually graduate with bachelor of science degrees. The result is expected to be, relative to this Nation's needs, a cumulative shortfall of several hundred thousand holders of B.S. degrees by the year 2000.

These expected personnel needs represent both replacement of existing workers as well as new personnel required to meet the expanding needs of an increasingly complex scientific and technological society. The projected annual shortfall of Ph.D. graduates, after considering those foreign students who will return home, is expected to be about 8,000 for the natural sciences and engineering.

Using figures from 1977 and the so-called pipeline model of scientist availability, Dr. Shakhashiri showed how 730,000 high school sophomores interested in the natural sciences and engineering, out of a total pool of 4 million students at that level, eventually progressed through the educational system, with students "leaking out" of various points in the pipeline, until only an estimated 10,000 received Ph.D. degrees. Such a small, final number represents a tremendous loss of scientific talent for the United States.

The problem becomes even more complicated when the population is divided into men and women. Strategies for recruiting and retaining women in science must necessarily be different. An additional problem is preventing the loss of minority scientific talent. Last year, for example, only five black students received Ph.D. degrees in mathematics. In the next 25 years, however, the proportion of minority students is expected to rise from about 18 percent to about 40 percent.

Elementary school students from the United States when tested and compared with students from other countries fare relatively poorly. Similarly, even U.S. high school students studying physics, chemistry, or biology do not appear particularly strong on the basis of international testing. These conclusions remain even after the data are normalized for differences in the total number of students attending high school from the different countries.

The question, said Dr. Shakhashiri, is what can be done about the present situation. Whereas the United States has talented students and the ability to deal with these issues, there is some question about whether the United States has the national determination to successfully solve the problems. Furthermore, we have a two-tier system, with U.S. universities and various national laboratories relatively science rich but local school systems relatively science poor. The science-rich sector, noted Dr. Shakhashiri, owes something to the science-poor sector.

The Federal Government provides support for both research and education in the sciences for national and economic security. However, students enter science for quite different reasons, particularly out of curiosity about nature. Somehow, the U.S. educational system stifles that interest after the third or fourth grade.

Dr. Shakhashiri emphasized the points of his talk by playing a portion of a videotape that underscores the lack of science literacy even in students graduating from Harvard University. The real challenge, he summarized, is finding ways to deal with science illiteracy. Despite having successful strategies at the tail-end of the pipeline, the United States must also devote some resources to strategies at the precollege level. The eventual solution to these problems will require a coordinated effort by many Federal agencies, not just the NSF.

Discussion

Dr. Goldhaber questioned how the United States can avoid the possibility of producing too many scientists. Dr. Shakhashiri admitted that the exact number of scientists needed remains unknown but that the focus should be on improving the quality of science education for all citizens. Dr. Mihich also questioned whether increases in science literacy could be integrated with increases in literacy in other subjects, such as history.

Dr. Shakhashiri mentioned that television programs such as "3-2-1 Contact" as well as science centers and museums, zoos, botanical gardens, and aquariums can also be mobilized as resources to interest youngsters in science. Dr. Hill noted that the United States had been warned over the past 15 years about the possibility of a limited supply of future scientists. The key issue, he noted, is largely money that has not been forthcoming. And money appears to play a role in both students' selection of graduate schools and in career choice after graduate school to enter industry rather than academia. In addition, Dr. Shakhashiri noted, the proportion of the NSF's budget devoted to science education has decreased considerably from the 40-percent level it once held.

Dr. Preuss noted that reluctance of many students to even consider science might hinge on current perceptions that problems in obtaining research funds make a science career difficult and even undesirable. Dr. Shakhashiri agreed, noting that it appears the United States defines success as getting a grant funded.

Recruitment of Women and Minorities in Science

Dr. Sue Kemnitzer
Executive Director
Task Force on Women, Minorities, and
the Handicapped in Science and Technology

Dr. Kemnitzer began by providing some history of the development of the Task Force and the issuance of the report Changing America. She noted that between now and the year 2000, 25 million new workers (net amount) will have to be added to the labor force. Furthermore, the composition of this labor pool will change drastically, with white males decreasing from 47 percent to 15 percent and women and minorities taking their place. As a result, the Secretary of Health and Human Services (HHS) is putting together a planning group to formulate strategies for encouraging all young people, particularly women and minorities, toward science.

Future steps, noted Dr. Kemnitzer, will probably include a transfer of the MARC program concept to other Federal agencies. The NSF, for example, plans to apply the MARC model to the physical sciences. In addition, Dr. Kemnitzer would like to bring corporate leaders to Washington, under the sponsorship of the National Action Council of Minorities in Engineering, to discuss other action.

Women appear to be making some inroads in the biomedical sciences. In medical school, 30 percent of the students are now women. But what happens to these students after graduation is the basis for some concern. For example, out of 170 medical schools, only two have deans who are women. Similarly, a gap persists in salaries in the medical sciences between women and men with Ph.D's. These issues, she observed, do not depend on the quality of science teachers or the activities of local school boards for resolution.

Dr. Kemnitzer suggested that minority students, especially, be brought into the laboratory as soon as possible and that scientists act as role models for them. Thus, scientists should make a public commitment to help women and minorities obtain a science education and should encourage and befriend women and minority students as they progress through their graduate training.

Discussion

Dr. Bock noted that the Howard Hughes Medical Institute had already taken some initiative in encouraging students to become more interested in science. In response to Dr. Mihich's query about the disparity in salaries and responsibility between women and men, Dr. Kemnitzer noted that women may be less likely than men to make demands in the early stages of their careers, thereby helping to accelerate the gap between men and women that widens with time. Dr. Reider commented that money and responsibility tend to increase together and agreed with Dr. Mihich that whereas the salary differential is relatively easy to correct, the difference in responsibility often is not.

Dr. Cohen reiterated that regardless of supply and demand issues, students emerging from graduate and professional studies must be of high quality. Despite this quality, noted Dr. Kemnitzer, only a relatively small percentage of investigators who apply for an NIH or NSF grant will receive support. Such difficult odds are unlikely to encourage young people to think of science as a career.

II. INITIATIVES PRESENTLY PROPOSED OR UNDERWAY TO ADDRESS THE ISSUE

AFTERNOON SESSION

The National Initiative for Science and Technology Education

Dr. Jerod Loeb
Director, Division of Biomedical Science
American Medical Association

The afternoon session was chaired by Dr. Jay Moscowitz, who introduced the first speaker, Dr. Jerod Loeb. Dr. Loeb focused particularly on the National Initiative for Science and Technology Education and the role of the American Medical Association (AMA). The two themes, he observed, that resulted from a conference on Medicine for the 21st Century were the same as those mentioned by Dr. Shakhashiri: concern about the future availability of scientists and the level of public literacy in science. This conference led to the formation of an umbrella professional organization that became the planning group for the national initiative.

Efforts of this new coalition were underscored by a media conference called Strategies for Change, which had three major objectives: first, to direct the attention of the media to problems and limitations inherent in today's science and mathematics education; second, to direct political attention to issues related to science education; and, third, to develop a larger consensus group to discuss problems and recommend solutions.

Out of the Strategies for Change conference emerged several distinct themes. One was that science needed to use the media more effectively for educating and informing the public. Another was that increased Federal funding for education was unlikely due to the budget deficit. An additional theme stressed the need to address teacher training and competency in science and technology, including the issues of educational methods and salaries.

Specific recommendations included improving the curriculum, which must become more exciting with less emphasis simply on memorization; making schools a safer haven for learning; creating linkages between industry, colleges and universities, and elementary and secondary schools; increasing access for students into the pipeline model at various points; developing methods to capture student interest in science and to provide students with appropriate guidance; declaring a national emergency in science, technology, and mathematics education; reformulating alternate pathways and methods for teacher certification in science and mathematics; creatively harnessing the media, such as television, to enhance student interest in science; improving communication between the science community and the public; intervening with students at an earlier age; and developing novel approaches such as regional centers for excellence, national standards to measure achievement, and training programs for those who wish to become science advocates.

As a representative of the AMA, Dr. Loeb expressed concern about declining medical school enrollments. He also felt that public support for scientific research has declined, based on such occurrences as the animal rights movement and recent congressional hearings into allegations of science fraud. Dr. Loeb felt that because of their close relationships with patients, physicians can serve as effective advocates of science. For example, Young Physicians, a pilot program started by the AMA, brings physicians into elementary schools to talk about the importance of science in daily life.

The AMA is also preparing videotapes for use in high schools and colleges that discuss the challenges and rewards of a medical career. A biomedical research advocacy group, headed by former Senator Lowell Weicker, Jr., is being supported by the AMA for gaining further public support for science. Members of various professional organizations have also submitted suggestions for improving both the public science literacy and educational pipeline situations; the AMA is distributing these materials to whoever requests them.

In summary, said Dr. Loeb, surveys suggest that students have a misconception about science and that this needs to be remedied to get students interested in science careers. Changes in perception can occur through the family, the schools, or the physician, who can serve as a significant role model. In addition, getting the viewpoint of the biomedical community into the press remains an unfulfilled objective in many cases.

Project 2061

Dr. F. James Rutherford
Director, Science and Technology Education
American Association for the Advancement of Science

Dr. Rutherford began by noting that the issue of getting students interested in science careers dates back to at least 1950. Much more difficult than defining the problem is devising effective solutions to deal with it. Clearly, experience shows us that there are no easy solutions. Issues range from the quality of the curriculum and testing programs to the nature of the school environment and social and political concerns. Educational alterations have failed to keep pace with the rapid changes that have been occurring for some time in society and the world.

Attempts at change have been piecemeal, noted Dr. Rutherford. What is now called for are fundamental changes in the whole educational enterprise. For example, education must be treated as a national, rather than a local, issue. Politics of self-interest may be partially responsible. Advances in biomedicine have resulted in more older people, for example, who are further removed from educational issues than younger people with children still in school. Federal agencies faced with budget crunches are less willing to put money into education, which may take 30 years to produce dividends, than to put the money into support of research. Changes in administration may also produce disruptions in planning national programs.

The American Association for the Advancement of Science (AAAS), with support from the Mellon and Carnegie Foundations, is involved in determining what students need to learn about science, mathematics, and technology by the time they are 17 or 18 years old. The AAAS has brought panels together to discuss these problems as the first phase of a program expected to last through the next 25 years. It will take at least a generation, said Dr. Rutherford, to change the schools.

The AAAS report *Science for All Americans*, for example, defines in 12 chapters what constitutes literacy in science, mathematics, and technology. Rather than focusing on specific disciplines, it defines general notions, historical perspectives, ways of thinking, and ideas such as systems and scales that help people understand the world around them. These suggestions are targeted to all students, not only the best.

Six teams of kindergarten through 12th-grade teachers, supported by faculty and scientists from nearby universities, will incorporate these concepts into a curriculum model. These teams, located in culturally diverse communities around the country, will then create the educational models and define the resources needed for using them in the schools.

One objective of this program is to attract more minority students into science. The AAAS approach, however, is complicated, observed Dr. Rutherford, by the fact that the proportion of minority teaching faculty in science and mathematics is diminishing. Minority teachers are needed as role models for students.

Support from the Federal Government, said Dr. Rutherford, could accelerate efforts to attract minorities into science teaching. With support from the NSF, the AAAS will work on recruiting 150 teachers, many of whom will represent minority groups, to work on the curriculum design panels. The AAAS anticipates that these teachers will then become the leaders of future changes in the schools. A national strategy, rather than a patchwork approach, should help ensure success, although the actual outcome is difficult to predict.

Discussion

Dr. Goldhaber inquired about the outcome of previous projects to improve the teaching of high school physics. Dr. Rutherford believed that expectations about what those programs could accomplish were unrealistic. When the new curricula were put into the schools, their impact was too small and was achieved too slowly to mark them as a success. Long-term success could not be assured because of discontinuities in funding. However, educators learned how to motivate faculty at all levels of the educational system to work together to design new curricula. And the resulting courses were better and more interesting than those being used even now.

Dr. von Hippel wondered why current efforts, therefore, could not be built on these earlier efforts. Dr. Rutherford indicated that this could be done; however, a fundamental difference is that earlier efforts sought to change selected curricula whereas current efforts are also targeting changes within the schools themselves. Dr. Goldstein remarked that curricula changes may, to some extent, represent turf battles among various disciplines, both scientific and nonscientific. Dr. Rutherford indicated that the AAAS program includes the social sciences, history, technology, and engineering and represents efforts to alter the science culture, not just science alone.

Essential Changes in Secondary School Science—Scope, Sequence, and Coordination

Dr. LaMoine L. Motz
President
National Science Teachers Association

Dr. Motz reported that areas of improvement in the National Assessment of Educational Progress, a government-sponsored assessment program, could be traced to four factors: the use of various instructional techniques, the opportunities for hands-on learning of science, efforts to relate science to everyday life, and emphasis on the cultural value of science.

It is particularly important, noted Dr. Motz, that students recognize the process of thinking inherent in science, and not just the final collection of facts that result from identifying and solving problems. Dr. Motz has initiated a task force at the NSTA to look at evolving patterns of instruction in science laboratories at secondary schools around the country. He believes there is a need to upgrade and update both laboratory facilities and curricula.

Such concerns have evolved into four initiatives at the NSTA. The first is called Staff Development and Teacher Preparation, which involves establishing teacher certification codes for science teachers in elementary and secondary schools. A special focus is on staff development, including continuing education that enables teachers to go to conferences and workshops so they can keep up with the latest advances in science.

The second NSTA initiative deals with how the curriculum is presently structured and what reforms might be needed. A task force, for example, is working on the role of science and technology in society. The third initiative involves instructional support. The NSTA proposes to provide such support through regional science centers that will show teachers various technologies and other resources that can be integrated with current teaching materials such as textbooks. The NSF, for example, is currently funding eight new projects that focus on science curricula. Each project is related to a particular publisher who is taking responsibility for helping to develop these supporting materials.

The final initiative, said Dr. Motz, deals with the dissemination of research results through available new technologies such as videotape, computers, and compact discs. All of these initiatives depend on support from school principals and school boards, none of whom, judging from recent surveys, appear particularly comfortable with science.

Recently, the Council for Scientific Society Presidents, representing science organizations primarily but few science education groups, passed a resolution that endorses curriculum reforms requiring all students to study biology, chemistry, physics, and earth/space every year in grades 7 through 12.

Current assessment techniques now look at what students know. What is needed, however, are the Project 2061 efforts and others to define what an operational science curriculum is and what it can accomplish. Furthermore, science education in the primary and secondary schools needs to be better coordinated. Whereas students are taught science in elementary school, it is often "accidental, incidental, and seasonal." For example, teachers will emphasize leaves in the fall, insect collections in the spring. These students then enter junior and senior high school with a mixed content background. Reassessment of the science curriculum must consider these problems as well as the amount of time to be spent on science and how that time is to be distributed among such disciplines as biology, chemistry, physics, and mathematics. This requires looking at how each discipline should be broken up and taught in the various school grades. It also means determining how content will be distributed between descriptive science and theoretical or more abstract types of science experience.

Dr. Motz further emphasized the educational concept of spacing, which distributes the teaching of a particular discipline over time to increase retention and understanding. Dr. Motz then presented some examples of spacing physics and biology curricula over the 7th through 12th grades. These changes, he noted, are part of an ongoing effort by the NSTA to revise the science curriculum through the "Scope, Sequence, and Coordination in Secondary School" project now under development by the NSTA.

Discussion

Dr. Mihich felt that the task of science education is to strike a balance between giving students too much information and giving them just enough information to motivate their interest in science. Dr. Raub expressed concern about the proportion of science teachers coming from schools of education rather than university science departments. Dr. Palade emphasized that both institutional groups needed to work more closely in the preparation of science teachers.

III. DEVELOPMENT OF ADDITIONAL OPTIONS FOR INTERVENTION

Dr. Moskowitz moderated the meeting for the remainder of the afternoon. He noted that the essential ingredient for continued progress in biomedical research and clinical practice is a steady supply of well-trained and highly motivated young scientists interested in careers in biomedical research. A principal concern and opportunity for the NIH, therefore, is to provide the necessary training at the doctoral and postdoctoral levels.

New strategies are needed to do this in the face of demographic and sociological trends indicating a diminished supply of potential young investigators. Additional effort, said Dr. Moskowitz, must therefore focus on those factors that affect the quality of science education and career choices at all stages of the educational continuum. Indicators suggesting that by the year 2000 about 85 percent of new entrants into the Nation's workforce will be women and minorities means that outreach programs must be started now to interest these groups in science careers.

Panel Discussion: Development of Additional Options for Intervention

Mr. Ethan Halm
Medical Student
Yale University School of Medicine

Mr. Ethan Halm, a third-year medical student from Yale University School of Medicine, noted that despite years of professional medical and scientific training, medical graduates may leave the field of medicine for jobs in such unrelated areas as banking and management consulting. It is necessary, he said, to therefore retain physicians in medicine and to encourage them to enter research. An important factor to get students interested in a research career is to give them hands-on research experience in medical school.

Despite declines in the pool of medical school graduates, there has been an increase in the proportion of medical students involved in research. Several medical schools are currently providing research stipends, both during the summer and academic year, to their students. Yale, in particular, requires a thesis for graduation from medical school. As a result, all medical students at Yale are involved in some sort of research project. As the gap between earnings in private practice and research continues to narrow, an emphasis on the rewards of research should help in recruiting more physicians for a research career.

Dr. Rodman D. Starke
Vice President for Scientific Affairs
American Heart Association (AHA)

Dr. Starke noted that the AHA probably spends a larger proportion of its budget on research than any other voluntary health organization. This support is divided evenly between research projects and investigator training. Beginning with the Established Investigator Award in 1949, the AHA now also offers a Clinician Scientist Award and a Medical Student Fellowship that, unlike the other awards made to individuals, goes to a recipient institution. The AHA also features decentralized awards that permit AHA affiliates to also fund fellowship and grant-in-aid awards after extensive peer review of the applications. Some of these awards may be used to provide undergraduates with summer laboratory research experience. Funds to support such programs come from both private and corporate sources.

The foremost program of AHA support to individuals goes to certain established investigators and clinician/scientists. This program has a demonstrably low risk and, consequently, a high success rate. A program of higher risk, but critical importance, supports individuals entering research for the first time. Candidates are identified both through self-selection and recommendations by mentors and teachers. Such a program allows the identification of promising students who might otherwise be lost from the pool of potential biomedical researchers.

Dr. Williams asked whether the AHA has, or would consider, programs aimed at supporting high school students. Dr. Starke replied that certain such programs may already be occurring in some local jurisdictions and that the national organization could stimulate further development of them. Dr. Moskowitz inquired whether the AHA had evaluated the Medical Student Research award. Dr. Starke noted that the program was only 5 years old and therefore it was a little too early for valid assessment of this particular program.

Dr. Daniel F. Burton
Vice President, Council on Competitiveness

Dr. Burton began by suggesting that there are three reasons why the issue of biomedical manpower availability is so difficult to address. First is a tendency to think of a single cause rather than the possibility of multiple causes for insufficient supply. Second is the complex relationships among a whole set of issues that affects this problem. Third involves money. Although the United States, for example, outspends Japan and several other countries in the proportion of the gross national product devoted to public education, the United States is facing problems over the availability of future biomedical manpower.

The place to start, suggested Dr. Burton, is by establishing partnerships despite the fact that no clear consensus has emerged on leadership for dealing with this problem. The NIH, he thought, could take the lead role on this issue. Furthermore, because the medical and biotechnological sectors of the economy remain strong, the NIH's involvement is likely to attract more serious attention.

Whereas the private sector is willing to become involved in these issues, Dr. Burton felt that the private sector cannot be responsible for assuming a leadership role. Dr. Burton cited the example of a partnership modeled on the American Electronics Association, which provided educational funds to permanent U.S. residents willing to pursue graduate studies in science and engineering. After graduating, those students who taught for 3 years did not have to repay the loans. Although it helped fund the program, the private sector learned from this experience that it really was not set up to administer such programs.

Another important issue, noted Dr. Burton, is the need to set clear goals that will catalyze activity. For example, curricula changes are critically needed along with methods for assessing whether educational goals are being met. Most important, there do not appear to be short-term solutions to issues involving the international competitiveness of U.S. students.

Ms. Rosemary Bruner
Director of Community Affairs
Hoffmann-La Roche, Inc.

Ms. Bruner began by pointing out that her responsibility consisted of developing programs in about 50 communities where Hoffmann-La Roche is located. Research, she noted, is the lifeblood of the company and therefore depends on a strong, continuous supply of investigators who successfully progress through the educational system. Today, for example, Roche's Institute of Molecular Biology helps train postdoctoral and graduate students. In addition, through the Community Affairs Department, Roche offers research opportunities to college students, high school students, and high school biology teachers. There is also a cooperative education program with about nine area high schools, which permits high school students to work part-time in the laboratory while continuing their education.

About 8 years ago, a delegation of Roche scientists from the Molecular Biology Institute asked for help in developing programs to deal with the impending crisis in biomedical manpower. One program that was started, but subsequently failed, depended on sending either active or retired scientists into the high schools to speak to students. Difficulties in communicating with those students, the failure of students to understand the context of research, and the fact that such speakers often are incorrectly perceived as making up for teacher deficiencies were factors that resulted in discontinuing this program.

From that experience Roche learned that the high school teacher and the major researcher have a common bond. Through the New Jersey Science Supervisor's Association, the Department of Community Affairs learned of instructional resources that science teachers need and, consequently, became involved in furnishing such resources. Roche investigators, for example, have helped develop curriculum content and have also held seminars to train teachers and provide classroom materials.

But the problem of interesting students in science extends far beyond classroom materials. Recruiting women and minorities into science requires also dealing with a range of societal problems not commonly encountered in the past. For example, the traditional science student, the white male, often comes from a family that provides role models, an enriched background, and an atmosphere in which learning and education are rewarded.

Because students now being recruited into science may not enjoy such advantages, Roche developed programs aimed at students in elementary and middle schools where career orientation often begins first. The latest program focuses on working with inner-city parents through black churches. The purpose of the program is to teach parents how to nurture and encourage the intellectual development of their children, particularly in families who have never had a close relationship with science or a scientist.

Dr. Abraham asked whether a profile of the high school science teacher existed that permits identifying good science teachers and developing national uniformity for their educational requirements.

Ms. Bruner remarked that, like science students, the profile of high school science teachers is rapidly changing. One reason is that teachers are taking laboratory jobs in industry where they make more money. The State of New Jersey has helped to partially rectify this problem by raising teacher salaries.

The issue of educational uniformity for teachers is a difficult one, given the current debate over whether science teachers should be trained in a university science department or an education department. The best high school teacher appears to be one who likes the discipline first, and who also enjoys teaching. The impact of good teachers is nullified somewhat by the fact that students best prepared to study science still come from enriched school districts, primarily those in the suburbs.

Dr. W. Maxwell Cowan
Vice President and Chief Scientific Officer
Howard Hughes Medical Institute

Dr. Cowan began by noting that the state of the scientific enterprise in the United States, particularly biomedical research, is in excellent shape. The steady stream of foreign scientists to this country at some point in their training or careers attests to this fact. Despite deficiencies in the kindergarten, elementary, and secondary school levels, U.S. students who enter graduate school are superbly well trained and, when they graduate, comparable to the best students in the world.

Yet problems are evident, particularly in the intramural program at the NIH, which is facing difficulties in recruiting senior scientists. The major reason for this is the loss of a generation of superb graduate and medical students who want to go on to careers in biomedical science but have not had the traditional opportunity for training. Those opportunities were lost when the National Defense Education Act fellowships were abruptly cut off and training grants held up. One of the strongest recommendations possible to the Director of NIH, said Dr. Cowan, would be to press for the reintroduction of training grants and training support at levels comparable to those in the late 1960's and early 1970's. This should also include summer fellowships for medical students, which in the past introduced medical students to laboratory research.

Another area of concern is the failure of medical graduates to enter biomedical research in large numbers. NIH grants to physicians, for example, have continuously declined. Part of the reason is the inadequacy of this country's current training system. The indebtedness that confronts medical students and the long periods of residency training means that some way to substantially underwrite the training of physicians is necessary to attract them into biomedical research. Equally daunting is the prospect of spending up to 40 years applying for research grants against increasing competition from bright young people moving out of the pipeline.

Dr. Cowan recommended that the NIH press hard for reinstatement of training at every level from medical school through postgraduate training, by increasing both the number of training grants and their annual stipends. Dr. Cowan also suggested that the NIH consider converting its intramural program into the core of a graduate university. Attracting young people to the NIH campus to obtain training not available through the educational system is a great attribute of the NIH intramural program.

Dr. Robert W. Krauss
Executive Director
Federation of American Societies for Experimental Biology (FASEB)

Dr. Krauss agreed with Dr. Cowan that the U.S. system of education does many things well but felt that improvements were also needed. The extremely long training periods routine now for students drains some of the energy and drive inherent in younger students. Dr. Krauss suggested that students be put into research or medical practice as quickly as possible, rather than assuming they need to be taught everything in school. Bright and properly trained people, he noted, know how to get the knowledge necessary to accomplish a specific task.

Because the educational enterprise in the United States is large and represents a $200 to $400 billion investment, improvement of science education will require a substantial, but not impossible, effort. Efforts by the Federal Government to improve other problems with a similar order of magnitude, such as the Savings and Loan industry, are currently ongoing. Clearly, however, the Federal Government, rather than local jurisdictions, must take a leadership role on education issues.

Whereas money represents an important solution to these problems, the way to best spend that money to accomplish goals is equally important. FASEB has developed several intervention programs. One involves sending out some 400 scientists for several days to talk to students at minority institutions. These scientists have visited some 200 institutions at a small annual cost of between $70,000 and $90,000.

Dr. Krauss noted that such programs of scientist visitations at high schools could work under the proper conditions. When those conditions are met, the results can be dramatic. FASEB is hoping to become further involved in interacting with students in kindergarten through the 12th grade. Several FASEB societies have also developed an intern program that subsidizes laboratory experiences for teachers from liberal arts colleges during the summer.

Dr. Ruby P. Hearn
Vice President
Robert Wood Johnson Foundation

Dr. Hearn began by pointing out that the Robert Wood Johnson Foundation represents the largest health care philanthropy in the country and has operated since 1972. Currently, the Foundation provides nearly $100 million in grants annually to address America's health care problems. Since 1972, some $50 million has been awarded for programs in high schools and colleges with a good track record in producing minority health personnel, particularly physicians. This included support for educational programs for minority high school and college students, financial aid for minority medical institutions, and postdoctoral fellowships.

In 1983, the Foundation began the Minority Medical Faculty Development Program. Only 2.9 percent of about 35,000 medical school faculty come from minority groups. An important part of the program involves mentors who support and encourage student careers in science generally, and biomedical research specifically. A 4-year fellowship requires that fellows spend 70 percent of their time in research. The Foundation provides students with a stipend of $50,000 and provides an additional $25,000 to support the fellow's research. Awards are made for an initial 2-year period, which can then be renewed.

A committee of senior investigators helps review credentials and research plans of the applicants; candidates are also interviewed. In addition, a 4-year plan by the applicants and their mentors is also considered. To be eligible, physician candidates must express a commitment to pursue a career in academic medicine. The Foundation monitors progress throughout the fellowship program and each year provides each fellow with the opportunity to make a scientific presentation that is reviewed by an advisory committee. Representatives of the Foundation then meet with each fellow and his or her mentor to discuss the candidate's progress.

This program has attracted a large number of extremely talented minority physicians anxious to pursue careers in biomedical research. Although the applicant pool had declined somewhat in previous years, it has doubled over the past year due to an increase in the fellowship stipend. If more resources were available, the number of fellows could certainly increase further.

Discussion

Using the pipeline model, Dr. Palade suggested that a serious problem occurs at the high school level. Students in high school and middle school are at their most receptive levels and have a chance to become scientifically literate before going on to college. Yet studies indicate a sharp drop in interest in science for these same school populations. What is missing, Dr. Palade believes, is teachers of adequate quality.

In Europe, science and mathematics teachers are university graduates and carry the title of master, meaning they are qualified to teach in high school. Such a system introduced into the United States would increase the quality of science teaching in high school and middle school. It would also lead to increased salaries for science teachers and, thereby, increased appeal and respect. It would provide a reasonable, additional alternative for science majors who decide not to pursue a graduate degree. As the pool of science applicants enlarges, industry will benefit and science literacy, in general, will increase. In fact, noted Dr. Palade, it would be worthwhile having another meeting in the future to discuss these problems and options.

Dr. Scharff addressed the issue of science training in the average, small liberal arts college. Studies showed, for example, that many recipients of Pew scholarships came from small towns and small liberal arts colleges. These students, when interviewed, recalled going into science in spite of, not because of, the science training they had received in these institutions, which they considered to be poor. In fact, 50 percent of the current leading young Ph.D. and M.D./Ph.D. candidates are from just such colleges.

Dr. Scharff also indicated that industry, which is a major employer of scientists, needed to provide more training assistance. One program in New Jersey, for example, associated with Drew University, sends people who have finished their scientific or administrative careers to fill science faculty positions at small colleges. Such programs are necessary because the quality of young people going into science appears to be dropping precipitously.

Dr. Mihich indicated that he believed both the quantity as well as the quality of science students is dropping. Another key issue concerns money. The funding of only 25 percent of all approved grants provides little incentive for students to embark on research careers. The loss of training programs makes it difficult for those students still interested in science careers to enter the field. There is also a need to provide stability in some of the NIH research career fellowship programs. This money, he indicated, would be well spent because medical research remains one of this country's best investments. But, he emphasized, the scientific community must continue to press Congress to provide the necessary funds.

Dr. von Hippel commented that whereas biomedical education has succeeded in producing outstanding graduates, the educational system is in serious danger of eroding. He believes that the most immediate need is to scale up the training grants without affecting funds for the RO1 grants. Dr. Raub noted that scientists testifying recently before the Congressional Appropriations Committees have emphasized the need for increased funding but that the figures presented in virtually every case have appeared to far exceed what overall budget assessments could allow. Particularly serious is the annual nature of the budget cycle that tends to focus on, and emphasize, short-range strategies rather than long-range plans extending from 5 to 25 years into the future.

Dr. Raub mentioned that Dr. Wyngaarden had instituted efforts to maximize the training resources currently available at the NIH. For example, areas where fellowships have gone unclaimed can now be recycled into fellowship programs in other areas. Each of the separate institutes has worked on such strategies. In addition, the NIH has proposed to the White House that some research project grant funds be shifted into the area of training. Right now the key issues are whether the White House will agree to do this; if so, what proposals will emerge; and how these proposals will be received in Congress. But, said Dr. Mihich, these questions are likely to lead to persistent discussion before a consensus is reached.

Dr. Krauss pointed out that FASEB spends more than $500,000 each year to discuss such questions with both congressional staffs and members of the Office of Management and Budget. Dr. von Hippel reiterated the concern that tradeoffs and shifting of funds could have impacts on the educational pipeline but might not necessarily address the key need for more funding, in general.

Dr. Moskowitz brought the discussion to closure and indicated that recommendations from these discussions would be developed and presented to an ad hoc panel appointed by Dr. Wyngaarden to look at issues on training the next generation of scientists.

In summary, Dr. Raub thanked the participants for their help and observed that the Advisory Committee might be asked to review these issues again. It will be necessary, he noted, for the NIH to both reaffirm its traditional role in the research training process while strongly advocating support for research and training within the executive branch on behalf of the biomedical community. The NIH will continue to focus on bringing physicians into research careers, attracting and retaining women and minorities in science and research, and finding better means for using existing training mechanisms. Additionally, the NIH will continue to develop collaborations with industry and foundations, remain involved in issues of science education in both secondary schools and colleges, and press for increased science literacy for the general public. As particular initiatives mature and problems emerge, the Advisory Committee to the Director, among others, will be asked for suggestions and advice.

I hereby certify that, to the best of my knowledge, the foregoing minutes are accurate and complete.

Jay Moskowitz, Ph.D., Executive Secretary
Advisory Committee to the Director, NIH

James B. Wyngaarden, M.D., Chairman
Advisory Committee to the Director, NIH

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May 18, 1989

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